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(54) **Digital audio scrambling system with error conditioning.**

(57) In the scrambling system, an analog audio signal is converted into a digital signal to provide a sequence of digital signal samples. Each digital signal sample is compressed to provide compressed signal samples having a sign bit, three exponent bits and seven mantissa bits. Each bit of each compressed signal sample is exclusive-OR'd with a unique keystream to thereby scramble the autio signal. A Hamming code generator generates code bits for correcting singular errors in a combination of the sign bit, the exponent bits and the code bits; and a parity bit generator generates a parity bit for detecting double errors in a combination of the sign bit, the exponent bits and the code bits and for further detecting an error in the most significant mantissa bit and/ or the parity bit. The bits from a plurality of successive compressed, error-encoded signal samples are interleaved and serialized in order to separate the bits from any single sample by at least a predetermined duration associated with an FM discriminator click. The serialized signal samples are combined to provide two-bit digital words. The digital words are converted to digital PAM data signals. The digital PAM data signals are converted to an analog signal to provide the pulse-amplitude-modulated signal. The descrambler system descrambles the scrambled audio signal. Singular errors in a scrambled signal sample are detected and corrected by a Hamming error corrector. Double errors are detected by a parity bit check and compensated for by repeating the last received error free signal sample.

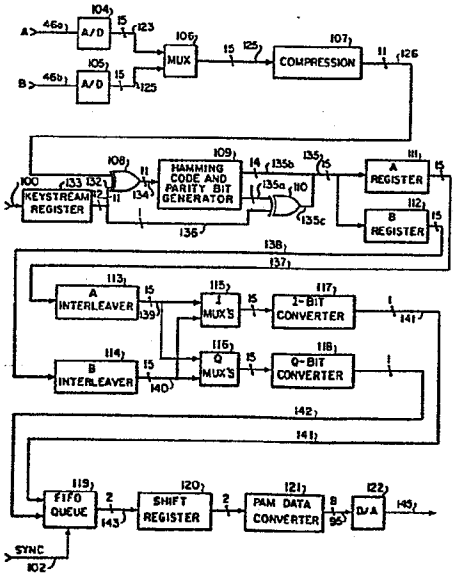

FIG. 1

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DIGITAL AUDIO SCRAMBLING SYSTEM WITH ERROR CONDITIONING

BACKGROUND OF THE INVENTION

The present invention generally pertains to audio signal processing and is particularly directed to improved audio signal scrambling and digital scrambling systems with error conditioning.

There are several prior art systems for scrambling and descrambling audio signals, including systems wherein an analog audio digital signal is converted to digital signal samples, and the bits of the samples are exclusive-OR'd with the bits of a unique keystream to scramble the signal.

There also are several prior art systems for conditioning digital signals for error detection and correction, including systems utilizing a Hamming code generator.

SUMMARY OF THE INVENTION

In one aspect of the present invention an audio scrambling system converts an analog audio signal into a digital signal to provide a sequence of digital signal samples corresponding to the analog audio signal; compresses each digital signal sample to provide compressed signal samples having a sign bit, a first given number of exponent bits and a second given number of mantissa bits; exclusive-OR's each bit of each compressed signal sample with a unique encryption keystream to thereby scramble the audio signal; generates error detection and correcting bits for each compressed signal sample and adds the generated bits thereto to provide error-encoded, compressed signal

samples. The error detection and correcting bits are generated by generating code bits for correcting singular errors in a combination of the sign bit, the exponent bits and the code bits; and by generating a parity bit for detecting double errors in a combination of the sign bit, the exponent bits and the code bits and for further detecting an error in the most significant mantissa bit and/or the parity bit.

Preferably bits from a plurality of successive samples are interleaved and serialized in order to separate the bits from any single sample by at least a predetermined duration associated with a given type of interference signal, such as a burst error associated with an FM discriminator click. Individual bits from the serialized, interleaved, error-encoded, compressed signal samples derived from the audio signal are combined to provide digital words; and

the digital words are converted to an analog signal having a level related to the binary value of the digital words. For a preferred embodiment, wherein the scrambled audio signal is derived from the audio portion of a television signal and scrambled for insertion in a scrambled television signal, each interval of the error-encoded, compressed scrambled signal corresponding to the duration of a video signal line is time compressed into an interval corresponding to the duration of a video signal horizontal sync pulse; and the time-compressed intervals of said time-compressed signal are transmitted at the video signal line rate.

The descrambling system of the present invention descrambles audio signals that are scrambled and error conditioned by the audio scrambling system of the present invention. The audio descrambling system detects singular errors in the combination of the sign bit, the exponent bits and the codes bits of each scrambled signal sample and corrects the singular error; detects double errors in the combination of the sign bit, the exponent bits and the code bits and further detects an error in the most significant mantissa bit and/or the parity bit of each scrambled signal sample and repeats the last previous error free signal sample to compensate for the detected double error and/or for the further detected error; exclusive-OR's each bit of each scrambled, compressed signal sample with the unique encryption keystream to thereby descramble the audio signal; expands each compressed signal sample into a digital signal sample that can be converted into the analog audio signal by digital-to-analog conversion; and converts the digital signal sample into the original analog audio signal.

When the scrambled signal was derived by interleaving bits from a plurality of successive samples and by serializing the interleaved bits in order to separate the bits from any single sample by at least a predetermined duration associated with a given type of interference signal, the descrambling system deserializes the interleaved bits; and deinterleaves the deserialized bits to reconstitute the signal samples.

When the scrambled signal was derived by combining individual bits from the serialized, interleaved, error-encoded, compressed signal samples derived from the audio signal to provide digital words and by converting the digital words to a scrambled analog signal having a level related to the binary value of the digital words, the descrambling system converts the scrambled analog signal into the digital words; and separates the digital words into the serialized, interleaved, error-encoded, compressed signal samples.

When each interval of the error-encoded, compressed, scrambled signal corresponding to the duration of a video signal line was time-compressed into an interval corresponding to the duration of a video signal horizontal sync pulse and inserted at the video signal line rate in a video signal containing a color burst signal during each video signal line; the descrambling system time-expands each time-compressed interval of the scrambled signal into an interval corresponding to the duration of a video signal line; wherein the time expansion is synchronized in response to the color burst signal.

Additional features of the present invention are described in relation to the description of the preferred embodiment.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 is a block diagram of the preferred embodiment of the audio scrambling system of the present invention.

Figure 2 shows the signal to quantization noise vs. input level characteristic of the compression system in the scrambling system of Figure 1.

Figure 3 is a block diagram of the signal-compression portion of the compression system in Figure 1.

Figure 4a is a block diagram of the A-channel interleaver in the system of Figure 1.

Figure 4b is a block diagram of the B-channel interleaver in the system of Figure 1.

Figure 5 is a block diagram of the preferred embodiment of the audio descrambling system of the present invention.

Figure 6a is a block diagram of the A-channel deinterleaver in the system of Figure 5.

Figure 6b is a block diagram of the B-channel deinterleaver in the system of Figure 5.

Figure 7 is a block diagram of the signal-expansion portion of the expansion system in the system of Figure 5.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiments of the digital audio scrambling and descrambling systems are used in the video scrambling and descrambling systems described in a co-pending U.S. Patent Application by Klein S. Gilhousen and Charles F. Newby, Jr. filed on even date herewith for "Key Signal Encryption and Distribution System for Controlling Scrambling and Selective, Remote Descrambling of Television Signals" and in a co-pending U.S. Patent Application by Jerrold A. Heller and Woo H. Paik filed on even date herewith for "Video Scrambling and Descrambling Systems", wherein they are referred to as "audio processors". The

same reference numerals are used for like components described both therein and herein. The entire disclosures of both co-pending applications are incorporated herein by reference.

Referring to Figure 1, the preferred embodiment of the digital audio scrambling system includes a first analog-to-digital (A/D) converter 104, a second A/D converter 105, a multiplexer (MUX) 106, a data compression system 107, a first exclusive-OR logic element 108, a Hamming Code and parity bit generator 109, a second exclusive-OR logic element 110, an A-channel register 111, a B-channel register 112, an A-channel interleaver 113, a B-channel interleaver 114, I-bit multiplexers 115, Q-bit multiplexers 116, an I-bit converter 117, a Q-bit converter 118, a FIFO queue 119, a shift register 120, a pulse-amplitude-modulated (PAM) data converter 121 and a digital-to-analog (D/A) converter 122.

The audio scrambling system of Figure 1 scrambles stereo audio signals received on A channel 46a and B channel 46b. The A/D converters 104, 105 convert analog audio signals on A and B channels 46a, 46b into 15-bit digital signal samples on lines 123 and 124 corresponding to the respective analog audio signals. The A/D converters 104, 105 sample the analog audio signals at a sampling rate of 44.055 kHz, which is the same as the sampling rate for NTSC video tape recorders. There are several reasons for this choice. Coherence with the video signal decreases the overall hardware complexity. This reduces costs and increases reliability. The consumer hardware currently available, VTR adapters and soon to be released Compact

Disc digital audio system, are compatible with this rate. A full twenty kHz frequency response is possible with 44.055 kHz which is not the case with 32 kHz.

Another reason to chose 44.055 kHz over 44.1 kHz lies in the video taping process. The 24 Hz cinema frame rate is converted to 30 Hz by repeating one frame in five, and the color frame rate, 29.97 Hz, is then created by slowing down slightly. However, for the video and audio to remain synchronous, the audio must also be slowed. The analogous procedure for audio would be to transcode 48 kHz digital audio to 44.1 kHz (assuming one didn't have 44.1 kHz to start with) and then play back the tape with the audio at a 44.055 kHz rate. This is the case because the ratio of 30/29.97 is exactly equal to 44.1/44.055. Since 48 kHz to 44.1 kHz transcoding will be required for compact disc production, no new hardware will be required for transcoding if 44.055 kHz is the sampling rate. And, finally, a considerable effort is being expended by industry toward cost reductions related to the Compact Disc System. Future satellite systems can utilize this advantage. The digital audio sampling rate clock is generated by dividing a four-times-color-burst (14.318 MHz)-derived clocking signal by 325.

The multiplexer 106 includes fifteen 2-to-1 line multiplexers which operate at the sampling rate of 44.055 kHz to place alternating 15-bit samples from channels A and B onto lines 125.

The compression system 107 compresses the fifteen-bit digital signal sample on lines 125 into an eleven-bit signal sample on lines 126 having a sign bit S, three

exponent bits EØ, E1 and E2 and seven mantissa bits MØ, M1, M2, M3, M4, M5 and M6. The signal-to-quantization noise vs. input level characteristic for the compression system 107 is shown in Figure 2.

Referring to Figure 3, the compression system 106 includes a sign and exponent read only memory (ROM) 127, a mantissa ROM 128 and an exclusive-OR logic element 129. The seven most significant bits of the 15-bit digital signal sample on lines 125 are used to address the sign and exponent ROM 127, which in turn provides the sign and exponent bits on lines 130. The seven least significant bits of the 15-bit digital signal on lines 125 and the sign and three exponent bits on lines 130 are combined to address the mantissa ROM 128, which provides the seven mantissa bits on lines 131. The 15 to 11 compression code implemented by the combination of the sign and exponent ROM 127 and the mantissa ROM 128 is set forth in Table 1.

TABLE 1

15 to 11 COMPRESSION

INPUT BINARY			OUTPUT BINARY
SIGN	EXPONENTS	MANTISSA	
1	111	A B C D E F G	1 1 A B C D E F G X X X X X X
1	110	A B C D E F G	1 0 1 A B C D E F G X X X X X
1	101	A B C D E F G	1 0 0 1 A B C D E F G X X X X
1	100	A B C D E F G	1 0 0 0 1 A B C D E F G X X X
1	011	A B C D E F G	1 0 0 0 0 1 A B C D E F G X X
1	010	A B C D E F G	1 0 0 0 0 0 1 A B C D E F G X
1	001	A B C D E F G	1 0 0 0 0 0 0 1 A B C D E F G
1	000	A B C D E F G	1 0 0 0 0 0 0 0 A B C D E F G
0	000	A B C D E F G	0 1 1 1 1 1 1 1 A B C D E F G
0	001	A B C D E F G	0 1 1 1 1 1 1 0 A B C D E F G
0	010	A B C D E F G	0 1 1 1 1 1 0 A B C D E F G X
0	011	A B C D E F G	0 1 1 1 1 0 A B C D E F G X X
0	100	A B C D E F G	0 1 1 1 0 A B C D E F G X X X
0	101	A B C D E F G	0 1 1 0 A B C D E F G X X X X
0	110	A B C D E F G	0 1 0 A B C D E F G X X X X X
0	111	A B C D E F G	0 0 A B C D E F G X X X X X X

The exclusive-OR element logic 129 scrambles the seven mantissa bits on lines 131 by exclusive-OR'ing them with the most significant exponent bit on line 130a. The compressed digital signal sample consisting of the scrambled seven mantissa bits on lines 126b and the sign and three exponent bits on lines 126a are scrambled by the exclusive-OR logic element 108, which exclusive-OR's each compressed digital signal sample on lines 126 with eleven

bits of a unique keystream provided on 132 from a keystream register 133 to provide a scrambled compressed signal sample on line 134. Preferably, the keystream provided in accordance with the Data Encryption Standard (DES) algorithm. The unique keystream is provided to the keystream register 133 via line 100 from a keystream generator (not shown).

The Hamming code and parity bit generator 109 generates error detection and correction bits for each compressed signal sample on lines 134 and adds the generated bits thereto to provide error-encoded, compressed signal samples on lines 135. The parity bit is provided on line 135a and the remaining bits are provided on lines 135b.

The exclusive-OR logic element 110 scrambles the parity bit on line 135a with a keystream bit on line 136 from the keystream register 133. The scrambled parity bit is provided on line 135c.

The Hamming code generator portion of generator 109 generates three code bits CØ, C1 and C2 for correcting singular errors in a combination of the sign bit S, the exponent bits EØ, E1 and E2 and the code bits CØ, C1 and C2. Code bit CØ is generated by exclusive-OR'ing the sign bit S, exponent bit EØ and exponent bit E2. Code bit C1 is generated by exclusive-OR'ing the sign bit S, exponent bit EØ and exponent bit E1. Code bit C2 is generated by exclusive-OR'ing exponent bits EØ, E1 and E2. The Hamming code for generating the code bits CØ, C1 and C2 is shown in Table 2.

TABLE 2

HAMMING CODE							
C2	C1	CØ	S	E2	E1	EØ	
0	0	0	0	0	0	0	
1	1	1	0	0	0	1	
1	1	0	0	0	1	0	
0	0	1	0	0	1	1	
1	0	1	0	1	0	0	
0	1	0	0	1	0	1	
0	1	1	0	1	1	0	
1	0	0	0	1	1	1	
0	1	1	1	0	0	0	
1	0	0	1	0	0	1	
1	0	1	1	0	1	0	
0	1	0	1	0	1	1	
1	1	0	1	1	0	0	
0	0	1	1	1	0	1	
0	0	0	1	1	1	0	
1	1	1	1	1	1	1	

The parity bit generator portion of the generator 109 generates a parity bit for detecting double errors in a combination of the sign bit S, the three exponent bits and the three code bits and for further detecting an error in the most significant mantissa bit and/or the parity bit. The parity bit P is generated by exclusive-OR'ing the sign S, exponent bit E1, exponent bit E2, mantissa bit M6 and "1".

The error-encoded signal samples derived from the A-channel 46a are buffered in the A-channel register 111 and the error-encoded signal samples derived from the B-channel 46b are buffered in the B-channel register 112.

The A-channel signal sample is provided on line 137 from the A-channel register 111 to the A-channel interleaver 113, which interleaves bits from a plurality of successive A-channel samples. The construction of the A-channel interleaver 113 is shown in Figure 4a, wherein each block is a one-sample-period delay element. It is seen from Figure 4a that bits M6 and EØ are not delayed; bits S and M2 are delayed by one sample period; bits M5 and C2 are delayed by two sample periods; bits E2 and M1 are delayed by three sample periods; bits M4 and C1 are delayed by four sample periods; bits E1 and MØ are delayed by five sample periods; and bits P, M3 and CØ are delayed by six sample periods.

The B-channel signal sample is provided on line 138 from the B-channel register 112 to the B-channel interleaver 114, which interleaves bits from a plurality of successive B-channel samples. The construction of the B-channel interleaver 114 is shown in Figure 4b, wherein each block is a one-sample-period delay element. It is seen from Figure 4b that bits S and M3 are not delayed; bits M6 and C2 are delayed by one sample period; bits E2 and M2 are delayed by two sample periods; bits M5 and C1 are delayed by three sample periods; bits E1 and M1 are delayed by four sample periods; bits M4 and CØ are delayed by five sample periods; and bits P, EØ and MØ are delayed by six sample periods.

The combination of the I-bit multiplexers 115, the Q-bit multiplexers 116, the I-bit converter 117 and the Q-bit converter 118 cooperate to serialize the interleaved bits on lines 139 and 140 from the A-channel and B-channel interleavers, 113, 114 respectively in order to separate the bits from any single signal sample by at least a predetermined duration associated with a given type of interference signal.

Burst errors typically are caused by FM discriminator clicks. By separating the bits from any single sample by at least the duration of an FM discrimination click, it is possible to spread the error burst so that only one bit in each error encoded signal sample on lines 137 and 138 is affected, whereby single bit errors can be detected and corrected by a Hamming code error corrector in the descrambler. Empirical results indicate that a separation distance of seven sample periods is adequate for error bursts associated with FM discriminator clicks.

Two-bit digital words containing bits I and Q are provided serially on lines 141 and 142 from the I-bit converter 117 and the Q-bit converter 118. The I-bit converter 117 is a 15-bit parallel-to-serial converter for providing the I-bit on line 141. The Q-bit converter 118 is a 15-bit parallel-to-serial converter for providing the Q-bit on line 142. The two-bit digital word on lines 141 and 142 subsequently is processed in such a manner (as described below) that there is a lower error rate in the I-bit position. The I-bit multiplexers 115 and the Q-bit multiplexers 116 combine the interleaved signal samples on lines 139 and 140 to place the sign bit S, the exponent

bits EØ, E1 and E2, the code bits CØ, C1 and C2 from both the A and B channels and the parity bit P from the A-channel in the I-bit position in the digital word by providing these eight to the I-bit converter 117, and to place the mantissa bits MØ through M6 from both the A and B channels and the parity bit P from the B channel in the Q-bit position in the digital word by providing these eight bits to the Q-bit converter 118.

Table 3 shows the serialization in time, the delay accomplished by interleaving, and the placement in the respective I and Q bit positions of the A and B channel signal samples on lines 137 and 138 accomplished by the interleavers 113, 114, the multiplexers 115, 116 and the converters 117, 118.

TABLE 3

TIME	DELAY	I	Q
0	6	P-A	P-B
1	0	S-B	M6-A
2	1	S-A	M6-B
3	2	E2-B	M5-A
4	3	E2-A	M5-B
5	4	E1-B	M4-A
6	5	E1-A	M4-B
7	6	EØ-B	M3-A
8	0	EØ-A	M3-B
9	1	C2-B	M2-A
10	2	C2-A	M2-B
11	3	C1-B	M1-A
12	4	C1-A	M1-B
13	5	CØ-B	MØ-A
14	6	CØ-A	MØ-B

In the preferred embodiment, wherein the scrambled audio signals are the audio portion of a television signal, the digital word signals on lines 141 and 142 are time-compressed by the FIFO queue 119. The FIFO queue 119 time-compresses each interval of the digital-word signals corresponding to the duration of a video signal line into an interval corresponding to the duration of a video signal horizontal sync pulse. Each time-compressed interval of signals is provided on lines 143 from the FIFO queue to the shift register 120 at the video signal line rate during the period normally occupied by the horizontal sync pulse in an

NTSC video signal line. During horizontal sync pulse interval, the two-bit words are provided on line 143 at a rate of 7.16 megasymbols per second. Forty-two bit pairs per horizontal sync pulse interval are sent. This corresponds to 42 bits for each of the two audio channels or 2.8 samples per channel per horizontal sync interval.

The time-compression and timing functions of the FIFO queue 119 are synchronized and clocked in response to synchronization control and timing signals provided on line 102 in response to synchronization control and timing signals generated in response to the detection of the color burst in the video signal. The derivation of the synchronization and timing signals on line 102 is described in more detail in the aforementioned U. S. Patent Application by Jerrold A. Heller and Woo H. Paik.

The two-bit digital words in the shift register 120 are converted by the PAM data converter 121 into 8-bit digital PAM data signals on lines 95, which when converted into an analog signal by digital-to-analog conversion provide a pulse-amplitude-modulated signal having a level related to the binary value of the digital words. The level coding is shown in Table 4. Decision thresholds are at 10, 30 and 50 IRE units.

TABLE 4

LEVEL CODING

TRANSMITTED LEVEL (IRE UNITS)		
60	1	0
40	1	1
20	0	1
0	0	0

The D/A converter 122 converts the digital PAM data signals on lines 95 to provide pulse-amplitude-modulated scrambled audio signals on line 145.

In the preferred embodiment, the scrambled audio signal is communicated as a component in a scrambled television signal during the interval normally occupied by the horizontal sync pulse in a video signal line. The insertion of the scrambled audio signal in the scrambled television signal is described in the aforementioned U.S. Patent Application by Heller and Paik.

The preferred embodiment of the audio signal descrambling system is shown in Figure 5. It descrambles scrambled audio signals scrambled by the scrambling system of Figure 1.

The descrambling system includes an A/D converter 250, a PAM data detector 251, a FIFO queue 252, an A-channel deinterleaver 253, a B-channel deinterleaver 254, an A-channel register 255, a B-channel register 256, a multiplexer 257, a keystream register 258, a Hamming code error corrector 259, a first exclusive-OR logic element

260, a parity check logic element 261, a second exclusive-OR logic element 262, an error compensator 263, an expansion system 264, a demultiplexer 265, a first D/A converter 266, and a second D/A converter 267.

The A/D converter 250 converts a scrambled analog audio signal received on line 227 into an 8-bit digital PAM data signal which is provided on lines 269 to the PAM data detector 251. The PAM data detector 251 converts the PAM data signals on lines 269 into two-bit digital words in accordance with the level code set forth in Table 4 and provides the two-bit digital words on lines 270 to the FIFO queue.

The FIFO queue 252 time-expands the time-compressed intervals of the digital word signals on lines 270 so that the digital words occurring on line 270 during an interval corresponding to the duration of a horizontal sync pulse are provided at regular intervals over an interval corresponding to the duration of an NTSC video signal line. The operation of the FIFO queue 252 in expanding the time-compressed digital word signals on lines 270 is synchronized and clocked in response to clocking signals and synchronization control signals provided on lines 243. The synchronization control signals on lines 243 are derived in response to detection of the color burst signal in the original video signal. Such derivation is described in the aforementioned U.S. Patent Application by Heller and Paik.

The FIFO queue 252 converts the serial digital words on lines 270 into parallel 15 bit signals and demultiplexes the these 15-bit signals into the interleaved signal

samples derived from the A-channel and B-channel interleavers 113 and 114, respectively, in the scrambling system of Figure 1. The 15-bit A-channel signal is provided on lines 271 to the A-channel deinterleaver 253; and the 15-bit B-channel signal is provided on lines 272 to the B-channel deinterleaver 254.

The A-channel deinterleaver 253 deinterleaves the interleaved signal sample on lines 271 to provide a signal sample on lines 273 where all of the bits are from a single signal sample provided on A-channel lines 137 to the A-channel interleaver 113 in the audio scrambling system of Figure 1. The construction of the A-channel deinterleaver 253 is shown in Figure 6A, wherein each block is a one-sample-period delay element. It is seen from Figure 6A that bits CØ, M3 and P are not delayed; bits MØ and E1 are delayed by one sample period; bits C1 and M4 are delayed by two sample periods; bits M1 and E2 are delayed by three sample periods; bits C2 and M5 are delayed by four sample periods; bits M2 and S are delayed by five sample periods; and bits EØ and M6 are delayed by six sample periods.

The B-channel deinterleaver 254 deinterleaves the interleaved signal sample on lines 272 to provide a signal sample on lines 274 wherein all of the bits are from a single sample provided on B-channel lines 138 to the B-channel interleaver in the audio scrambling system of Figure 1. The construction of the B-channel deinterleaver 254 is shown in Figure 6B, wherein each block is a one-sample-period delay element. It is seen from Figure 6B that bits MØ, EØ and P are not delayed; bits CØ and M4 are delayed by one sample period; bits M1 and E1 are delayed by

two sample periods; bits C1 and M5 are delayed by three sample periods; bits M2 and E2 are delayed by four sample periods; bits C2 and M6 are delayed by five sample periods; and bits M3 and S are delayed by six sample periods.

It is seen from Figures 4 and 6 that the combined delay time for each of the bits in each of the channels is six sample periods.

Table 5 shows the relationship between the serialized digital word signals on lines 270 and the delay provided by the deinterleavers 253 and 254 to provide the bits for the A and B channel signal samples on lines 273 and 274, respectively.

TABLE 5

TIME	DELAY	I	Q
1	0	C0-A	M0-B
1	1	C0-B	M0-A
2	2	C1-A	M1-B
3	3	C1-B	M1-A
4	4	C2-A	M2-B
5	5	C2-B	M2-A
6	6	E0-A	M3-B
7	0	E0-B	M3-A
8	1	E1-A	M4-B
9	2	E1-B	M4-A
10	3	E2-A	M5-B
11	4	E2-B	M5-A
12	5	S-A	M6-B
13	6	S-B	M6-A
14	0	P-A	P-B

The deinterleaved signal samples on lines 273 and 274 are provided to the A-channel register 255 and the B-channel register 256 and multiplexed by the multiplexer 257 to provide the parity bit P on line 275; the exponent bits EØ, E1 and E2, the code bits CØ, C1 and C2 and the sign bit S on lines 276; and the seven mantissa bits MØ through M6 on lines 277.

The Hamming code error corrector 259 examines the three code bits on lines 276 to detect singular errors in the combination of the exponent bits, code bits and sign bit and corrects any such singular errors. The three exponent bits and the sign bit corrected as necessary are provided by the Hamming code error corrector on lines 278. The error detection code employed by the Hamming code error corrector is shown in Table 6.

TABLE 6

C2	C1	CØ	BIT IN ERROR
0	0	0	NO ERROR
0	0	1	CØ
0	1	0	C1
0	1	1	S
1	0	0	C2
1	0	1	E2
1	1	0	E1
1	1	1	EØ

The exclusive-OR logic element 260 exclusive-OR's the parity bit P on line 275 with one bit of a unique keystream on line 279a from the keystream register 258 that is identical to the bit provided on line 136 to scramble the parity bit P on line 135a in the scrambling system of Figure 1. The exclusive-OR logic element 260 thereby provides a descrambled parity bit on line 280, which is processed by the parity check logic element 261 with the most significant mantissa bit M6 on line 277a and the error-corrected sign and exponent bits on lines 278 to detect double errors in the combination of the sign and exponent bits and the code bits on lines 276 and to further detect an error in the most significant mantissa bit and/or the parity bit. Such errors are detected when the parity check does not result in unity. The parity check is accomplished by exclusive-OR'ing the bits provided to the parity check logic element 261 on lines 277a, 278, and 280.

The exclusive-OR logic element 262 descrambles the seven mantissa bits on lines 277 and the sign bit and three exponent bits on lines 278 by exclusive-OR'ing these eleven bits with eleven bits of a unique keystream on line 279b from the keystream register 258 that are identical to the keystream bits provided on lines 132 to scramble the sign bit, three exponent bits and seven mantissa bits on lines 126 in the scrambling system of Figure 1.

The keystream bits provided by the keystream register on lines 279 are provided to the keystream register via lines 242 from a keystream generator (not shown). The system for providing a unique keystream to the keystream register 258 via lines 242 in the descrambling system of

Figure 5 that is identical to the unique keystream provided on lines 102 the keystream register 133 in the scrambling system of Figure 1 is described in the aforementioned U.S. Patent Application by Gilhousen and Newby, Jr., the entire disclosure of which is incorporated herein by reference.

The exclusive-OR logic element 262 provides the descrambled bits as a descrambled signal sample on lines 282 to the error compensator 263.

When errors are detected by the parity check logic element 261, an error signal is provided on line 283 to the error compensator 263. If an error signal is not provided on line 283, the error compensator 263, passes the eleven-bit descrambled signal sample from lines 282 to the expansion system 264 via lines 284. When an error signal is provided on line 283 the error compensator 263 compensates for the detected errors by repeating on lines 284 the last previous error free signal sample received on lines 282.

The expansion system 264 expands the 11-bit signal samples on lines 284 into a 15-bit digital signal sample on lines 285 that can be converted into an analog audio signal by digital-to-analog conversion.

Referring to Figure 7, the expansion system includes an exclusive-OR element 287, a mantissa ROM 288 and a sign and exponent ROM 289. The exclusive-OR logic element 287 descrambles the seven mantissa bits MØ through M6 on lines 284a by exclusive-OR'ing the seven mantissa bits with the most significant exponent bit E2 on line 284b. The descrambled mantissa bits are provided by the exclusive-OR element 287 on lines 290 and are combined with the three

exponent bits EØ, E1 and E2 and the sign bit S on lines 284c to address the mantissa ROM 288, which in turn provides the eight least significant bits of the expanded digital signal sample on lines 285a. The sign bit S and three exponent bits EØ, E1 and E2 on lines 285c also are used to address the sign and exponent ROM 289, which in turn provides the seven most significant bits of the expanded digital signal sample on lines 285b. The 11 to 15 expansion code implemented by the combination of the mantissa ROM 288 and the sign and exponent ROM 289 is set forth in Table 7.

TABLE 7

11 TO 15 EXPANSION

INPUT BINARY			OUTPUT BINARY
SIGN	EXPONENTS	MANTISSA	
1	111	A B C D E F G	1 1 A B C D E F G X X X X X X
1	110	A B C D E F G	1 0 1 A B C D E F G X X X X X
1	101	A B C D E F G	1 0 0 1 A B C D E F G X X X X
1	100	A B C D E F G	1 0 0 0 1 A B C D E F G X X X
1	011	A B C D E F G	1 0 0 0 0 1 A B C D E F G X X
1	010	A B C D E F G	1 0 0 0 0 0 1 A B C D E F G X
1	110	A B C D E F G	1 0 0 0 0 0 0 1 A B C D E F G
1	000	A B C D E F G	1 0 0 0 0 0 0 0 A B C D E F G
0	000	A B C D E F G	0 1 1 1 1 1 1 1 A B C D E F G
0	001	A B C D E F G	0 1 1 1 1 1 1 0 A B C D E F G
0	010	A B C D E F G	0 1 1 1 1 1 0 A B C D E F G X
0	011	A B C D E F G	0 1 1 1 1 0 A B C D E F G X X
0	100	A B C D E F G	0 1 1 1 0 A B C D E F G X X X
0	101	A B C D E F G	0 1 1 0 A B C D E F G X X X X
0	110	A B C D E F G	0 1 0 A B C D E F G X X X X X
0	111	A B C D E F G	0 0 A B C D E F G X X X X X X

The demultiplexer 265 separates the A-channel and B-channel digital sample signals provided sequentially on lines 285 and provides the separated signal samples on lines 291 and 292 respectively to the first and second D/A converters 266 and 267.

The first D/A converter 266 converts the A-channel digital signal samples on lines 291 to an analog audio signal on A-channel line 161a; and the second D/A converter 267 converts the B-channel digital signal samples on lines 292 to an analog audio signal on B-channel line 161b.

CLAIMS

1. A system for scrambling an audio signal, comprising

means for converting an analog audio signal into a digital signal to provide a sequence of digital signal samples corresponding to the analog audio signal;

means for compressing each digital signal sample to provide compressed signal samples having a sign bit, a first given number of exponent bits and a second given number of mantissa bits;

means for exclusive-OR'ing each bit of each compressed signal sample with a unique encryption keystream to thereby scramble the audio signal;

means for generating error detection and correcting bits for each compressed signal sample and adding said generated bits thereto to provide error-encoded, compressed signal samples, wherein the generating means comprises

means for generating code bits for correcting singular errors in a combination of the sign bit, the exponent bits and the code bits; and

means for generating a parity bit for detecting double errors in a combination of the sign bit, the exponent bits and the code bits and for further detecting an error in the most significant mantissa bit and/or parity bit.

2. A system according to Claim 1, further comprising means for interleaving bits from a plurality of successive samples; and means for serializing the interleaved bits in order to separate the bits from any single sample by at least a predetermined duration associated with a given type of interference signal.

3. A system according to Claim 2, wherein the predetermined duration corresponds to the duration of a burst error associated with an FM discriminator click.

4. A system according to Claim 2, further comprising means for combining individual bits from the serialized, interleaved, error-encoded, compressed signal samples derived from the audio signal to provide digital words; and means for converting the digital words to an analog signal having a level related to the binary value of the digital words.

5. A system according to Claim 4, wherein the means for converting the digital words comprises means for converting the digital words to digital PAM data signals which when converted to an analog signal by digital-to-analog conversion, provide a pulse-amplitude-modulated signal having a level related to the binary value of the digital words; and

means for converting the digital PAM data signals to said analog signal to provide said pulse-amplitude-modulated signal.

6. A system according to Claim 2, wherein the audio signal includes stereo audio components and the aforesaid means provide separate interleaved, error-encoded, compressed signal samples for the respective stereo audio components, the system further comprising

means for combining individual bits from the separate interleaved, error-encoded, compressed signal samples for the respective stereo audio components to provide a series of two-bit digital words, wherein the exponent bits and the code bits occupy the bit position in the digital words having the lower error rate and the mantissa bits occupy the other bit position in the digital words; and

means for converting the digital words to an analog signal having a level related to the binary value of the digital words.

7. A system according to Claim 6, wherein the means for converting the digital words comprises

means for converting the digital words to digital PAM data signals which when converted to an analog signal by digital-to-analog conversion, provide a pulse-amplitude-modulated signal having a level related to the binary value of the digital words; and

means for converting the digital PAM data signals to said analog signal to provide said pulse-amplitude-modulated signal.

8. A system according to Claim 1, further comprising means for exclusive-OR'ing the parity bit of each error-encoded sample with a bit from the unique encryption keystream.

9. A system according to Claim 1, wherein the means for exclusive-OR'ing the bits of the compressed signal sample does so prior to generation of the code bits by the generating means.

10. A system according to Claim 1, further comprising means for time-compressing each interval of said error-encoded, compressed scrambled signal corresponding to the duration of a video signal line into an interval corresponding to the duration of a video signal horizontal sync pulse; and

means for transmitting said time-compressed intervals of said time-compressed signal at the video signal line rate.

11. A system for scrambling an audio signal, comprising means for converting an analog audio signal into a digital signal to provide a sequence of digital signal samples corresponding to the analog audio signal;

means for compressing each digital signal sample to provide compressed signal samples having a sign bit, a first given number of exponent bits and a second given number of mantissa bits;

means for interleaving bits from a plurality of successive samples; and

means for serializing the interleaved bits in order to separate the bits from any single sample by at least a predetermined duration associated with a given type of interference signal.

12. A system according to Claim 11, wherein the predetermined duration corresponds to the duration of a burst error associated with an FM discriminator click.

13. A system according to Claim 11, further comprising

means for combining individual bits from the serialized, interleaved, compressed signal samples derived from the audio signal to provide digital words; and

means for converting the digital words to an analog signal having a level related to the binary value of the digital words.

14. A system according to Claim 11, wherein the audio signal includes stereo audio components and the aforesaid means provide separate interleaved, compressed signal samples for the respective stereo audio components, the system further comprising

means for combining individual bits from the separate interleaved, compressed signal samples for the respective stereo audio components to provide a series of two-bit digital words, wherein the exponent bits and the code bits occupy the bit position in the digital words having the lower error rate and the mantissa bits occupy the other bit position in the digital words; and

means for converting the digital words to an analog signal having a level related to the binary value of the digital words.

15. A system according to Claim 14, wherein the means for converting the digital words comprises

means for converting the digital words to digital PAM data signals which when converted to an analog signal by digital-to-analog conversion, provide a pulse-amplitude-modulated signal having a level related to the binary value of the digital words; and

means for converting the digital PAM data signals to said analog signal to provide said pulse-amplitude-modulated signal.

16. A system according to Claim 11, further comprising

means for time-compressing each interval of said error-encoded, compressed scrambled signal corresponding to the duration of a video signal line into an interval corresponding to the duration of a video signal horizontal sync pulse; and

means for transmitting said time-compressed intervals of said time-compressed signal at the video signal line rate.

17. A system for descrambling a scrambled audio signal that was derived by converting an analog audio signal into a digital signal to provide a sequence of digital signal samples corresponding to the analog audio signal, by compressing each digital signal sample to provide

compressed signal samples having a sign bit, a first given number of exponent bits and a second given number of mantissa bits, by exclusive-OR'ing each bit of each compressed signal sample with a unique encryption keystream to thereby scramble the audio signal, and by generating error detection and correcting bits for each compressed signal sample and adding said generated bits thereto to provide error-encoded, compressed signal samples, wherein each error-encoded, compressed signal sample includes code bits for correcting singular errors in a combination of the sign bit, the exponent bits and the code bits, and a parity bit for detecting double errors in a combination of the sign bit, the exponent bits and the code bits and for further detecting an error in the most significant mantissa bit and/or the parity bit, the system comprising

means for detecting singular errors in the combination of the sign bit, the exponent bits and the codes bits of each scrambled signal sample and for correcting said singular error;

means for detecting double errors in the combination of the sign bit, the exponent bits and the code bits and for further detecting an error in the most significant mantissa bit and/or the parity bit of each scrambled signal sample and for repeating the last previous error free signal sample to compensate for said detected double error and/or for said further detected error;

means for exclusive-OR'ing each bit of each scrambled, compressed signal sample with the unique encryption keystream to thereby descramble the audio signal;

means for expanding each compressed signal sample into a digital signal sample that can be converted into the analog audio signal by digital-to-analog conversion; and

means for converting the digital signal sample into the analog audio signal.

18. A system according to Claim 17, wherein the scrambled signal was further derived by interleaving bits from a plurality of successive samples and by serializing the interleaved bits in order to separate the bits from any single sample by at least a predetermined duration associated with a given type of interference signal, the system further comprising

means for deserializing the interleaved bits; and

means for deinterleaving the deserialized bits to reconstitute the signal samples.

19. A system according to Claim 18, wherein the predetermined duration corresponds to the duration of a burst error associated with an FM discriminator click.

20. A system according to Claim 18, wherein the scrambled signal was further derived by combining individual bits from the serialized, interleaved, error-encoded, compressed signal samples derived from the audio signal to provide digital words and by converting the digital words to a scrambled analog signal having a level related to the binary value of the digital words, the system further comprising

means for converting the scrambled analog signal into said digital words; and

means for separating said digital words into said serialized, interleaved, error-encoded, compressed signal samples.

21. A system according to Claim 20, wherein the scrambled signal was derived by converting the digital words to digital PAM data signals which when converted to an analog signal by digital-to-analog conversion, provide a pulse-amplitude-modulated signal having a level related to the binary value of the digital words and by converting the digital PAM data signals to said analog signal to provide said pulse-amplitude-modulated signal, the system comprising

means for converting the pulse-amplitude-modulated signal to said digital PAM data signals; and

means for converting said PAM data signals to said digital words.

22. A system according to Claim 18, wherein the analog audio signal included stereo audio components and the scrambled signal was derived by providing separate interleaved, error-encoded, compressed signal samples for the respective stereo audio components, by combining individual bits from the separate interleaved, error-encoded, compressed signal samples for the respective stereo audio components to provide a series of two-bit digital words, wherein the exponent bits and the code bits occupy the bit position in the digital words having the

lower error rate and the mantissa bits occupy the other bit position in the digital words, and by converting the digital words to an analog signal having a level related to the binary value of the digital words, the system further comprising

means for converting the scrambled analog signal to said digital words; and

means for separating said digital words into said separate interleaved error-encoded, compressed signal samples.

23. A system according to Claim 22, wherein the scrambled signal was derived by converting the digital words to digital PAM data signals which when converted to an analog signal by digital-to-analog conversion, provide a pulse-amplitude-modulated signal having a level related to the binary value of the digital words, and by converting the digital PAM data signals to said analog signal to provide said pulse-amplitude-modulated signal, the system comprising

means for converting the pulse-amplitude-modulated signal to said digital PAM data signals; and

means for converting said PAM data signals to said digital words.

24. A system according to Claim 17, wherein the scrambled signal was further derived by exclusive-OR'ing the parity bit of each error-encoded sample with a bit from the unique encryption keystream, the system further comprising

means for exclusive-OR'ing the parity bit of each scrambled compressed signal sample with encryption keystream.

25. A system according to Claim 17, wherein the scrambled signal was derived by exclusive-OR'ing the bits of the compressed signal sample prior to generation of the code bits by the generating means, wherein within said system, the means for exclusive-OR'ing each bit of each scrambled compressed signal does so following said error detection and correction or compensation.

26. A system according to Claim 17, wherein each interval of said error-encoded, compressed, scrambled signal corresponding to the duration of a video signal line was time-compressed into an interval corresponding to the duration of a video signal horizontal sync pulse and inserted at the video signal line rate in a video signal containing a color burst signal during each video signal line; the system further comprising

means for time-expanding each said time-compressed interval of said scrambled signal into said interval corresponding to the duration of said video signal line; and

means for synchronizing said time expansion in response to said color burst signal.

27. A system for descrambling a scrambled audio signal that was derived by converting an analog audio signal into a digital signal to provide a sequence of digital signal samples corresponding to the analog audio signal, by compressing each digital signal sample to provide compressed signal samples having a sign bit, a first given number of exponent bits and a second given number of mantissa bits, by interleaving bits from a plurality of successive samples and by serializing the interleaved bits in order to separate the bits from any single sample by at least a predetermined duration associated with a given type of interference signal, the system comprising

means for deserializing the interleaved bits; and

means for deinterleaving the deserialized bits to reconstitute the signal samples.

means for exclusive-OR'ing each bit of each scrambled, compressed signal sample with the unique encryption keystream to thereby descramble the audio signal;

means for expanding each compressed signal sample into a digital signal sample that can be converted into the analog audio signal by digital-to-analog conversion; and

means for converting the digital signal sample to the analog audio signal.

28. A system according to Claim 27, wherein the predetermined duration corresponds to the duration of a burst error associated with an FM discriminator click.

29. A system according to Claim 27, wherein the scrambled signal was further derived by combining individual bits from the serialized, interleaved, error-encoded, compressed signal samples derived from the audio signal to provide digital words and by converting the digital words to a scrambled analog signal having a level related to the binary value of the digital words, the system further comprising

means for converting the scrambled analog signal into said digital words; and

means for separating said digital words into signal serialized, interleaved, error-encoded, compressed signal samples.

30. A system according to Claim 27, wherein the analog audio signal included stereo audio components and the scrambled signal was derived by providing separate interleaved, compressed signal samples for the respective stereo audio components, by combining individual bits from the separate interleaved, compressed signal samples for the respective stereo audio components to provide a series of two-bit digital words, wherein the exponent bits and the code bits occupy the bit position in the digital words having the lower error rate and the mantissa bits occupy the other bit position in the digital words, and by converting the digital words to an analog signal having a level related to the binary value of the digital words, the system further comprising

means for converting the scrambled analog signal to said digital words; and

means for separating said digital words into said separate interleaved, compressed signal samples.

31. A system according to Claim 30, wherein the scrambled signal was derived by converting the digital words to digital PAM data signals which when converted to an analog signal by digital-to-analog conversion, provide a pulse-amplitude-modulated signal having a level related to the binary value of the digital words and by converting the digital PAM data signals to said analog signal to provide said pulse-amplitude-modulated signal, the system comprising

means for converting the pulse-amplitude-modulated signal to said digital PAM data signals; and

means for converting said PAM data signals to said digital words.

32. A system according to Claim 27, wherein each interval of said error-encoded, compressed, scrambled signal corresponding to the duration of a video signal line was time-compressed into an interval corresponding to the duration of a video signal horizontal sync pulse and inserted at the video signal line rate in a video signal containing a color burst signal during each video signal line; the system further comprising

means for time-expanding each said time-compressed interval of said scrambled signal into said interval corresponding to the duration of said video signal line; and

means for synchronizing said time expansion in response to said color burst signal.

33. A system for scrambling an audio signal, comprising

means for converting an analog audio signal into a digital signal to provide a sequence of digital signal samples corresponding to the audio signal;

means for compressing each digital signal sample to provide compressed signal samples having a sign bit, three exponent bits and a given number of mantissa bits;

means for exclusive-OR'ing each bit of each compressed signal sample with a unique encryption keystream to thereby scramble the audio signal;

means for generating error detection and correcting bits for each compressed signal sample and adding said generated bits thereto to provide error-encoded, compressed signal samples, wherein the generating means comprises

a Hamming code generator for generating three code bits for correcting singular errors in a combination of the sign bit, three exponent bits and the three code bits; and

means for generating a parity bit for detecting double errors in a combination of the sign bit, the exponent bits and the code bits and for further detecting an error in the most significant mantissa bit and/or the parity bit.

34. A system according to Claim 33, further comprising means for interleaving bits from a plurality of successive samples;

means for serializing the interleaved bits in order to separate the bits from any single sample by at least a predetermined duration associated with a given type of interference signal;

means for combining individual bits from the serialized, interleaved, error-encoded, compressed signal samples derived from the audio signal to provide two-bit digital words; and

means for converting the digital words to a four-level pulse-amplitude-modulated analog signal having a level related to the binary value of the digital words.

35. A system for descrambling a scrambled audio signal that was derived by converting an analog audio signal into a digital signal to provide a sequence of digital signal samples corresponding to the analog audio signal, by compressing each digital signal sample to provide compressed signal samples having a sign bit, three exponent bits and a given number of mantissa bits, by exclusive-OR'ing each bit of each compressed signal sample with a unique encryption keystream to thereby scramble the audio signal, and by generating three error detection and correcting bits for each compressed signal sample and adding said generated bits thereto to provide error-encoded, compressed signal samples, wherein each error-encoded, compressed signal sample includes said three code bits for correcting singular errors in a combination of the

sign bit, the exponent bits and the code bits, and a parity bit for detecting double errors in a combination of the sign bit, the exponent bits and the code bits and for further detecting an error in the most significant mantissa bit and/or parity bit, the system comprising

a Hamming code error corrector for detecting singular errors in the combination of the sign bit, the exponent bits and the codes bits of each scrambled signal sample and for correcting said singular error;

means for detecting double errors in the combination of the sign bit, the exponent bits and the code bits and for further detecting an error in the most significant mantissa bit and/or the parity bit of each scrambled signal sample and for repeating the last previous error free signal sample to compensate for said double error;

means for exclusive-OR'ing each bit of each scrambled, compressed signal sample with the unique encryption keystream to thereby descramble the audio signal;

means for expanding each compressed signal sample into a digital signal sample that can be converted into the analog audio signal by digital-to-analog conversion; and

means for converting the digital signal sample into the analog audio signal.

36. A system according to Claim 35, wherein the scrambled signal was further derived by interleaving bits from a plurality of successive samples, by serializing the interleaved bits in order to separate the bits from any single sample by at least a predetermined duration associated with a given type of interference signal, by

combining individual bits from the serialized, interleaved, error-encoded, compressed signal samples derived from the audio signal to provide two-bit digital words and by converting the digital words to a scrambled, four-level pulse-amplitude-modulated analog signal having a level related to the binary value of the digital words, the system further comprising

means for converting the scrambled four-level pulse-amplitude-modulated analog signal into said two-bit digital words;

means for separating said two-bit digital words into said serialized, interleaved, error-encoded, compressed signal samples;

means for deserializing the interleaved bits; and

means for deinterleaving the deserialized bits to reconstitute the signal samples.

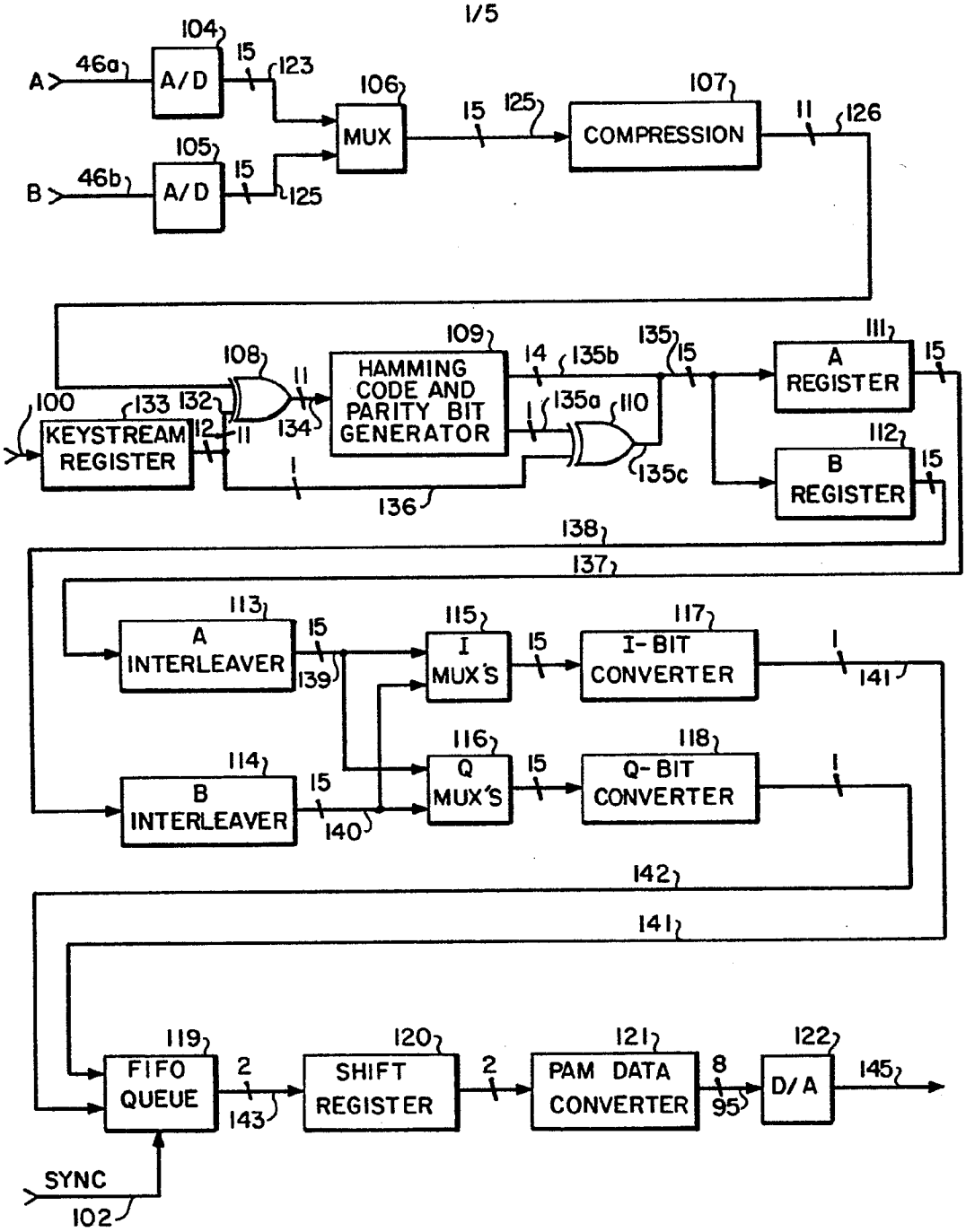
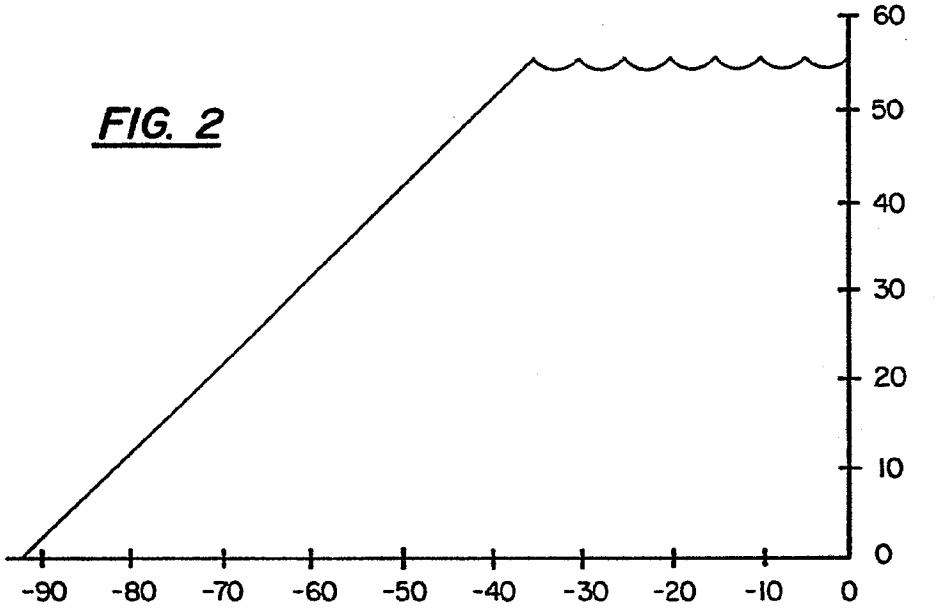

A
46a
A/D
104
15
123
B
46b
A/D
105
15
125
MUX
106
15
125
COMPRESSION
107
11
126
100
KEYSTREAM REGISTER
133
132
12
11
108
11
134
HAMMING CODE AND PARITY BIT GENERATOR
109
14
135b
135
15
1
135a
110
135c
136
A REGISTER
111
15
B REGISTER
112
15
138
137
A INTERLEAVER
113
15
139
I MUX'S
115
15
I-BIT CONVERTER
117
1
141
B INTERLEAVER
114
15
140
Q MUX'S
116
15
Q-BIT CONVERTER
118
1
142
141
FIFO QUEUE
119
2
143
SHIFT REGISTER
120
2
PAM DATA CONVERTER
121
8
95
D/A
122
145
SYNC
102

FIG. 1

FIG. 2



SIGNAL TO QUANTIZATION NOISE VS. INPUT LEVEL +20 dbm INPUT

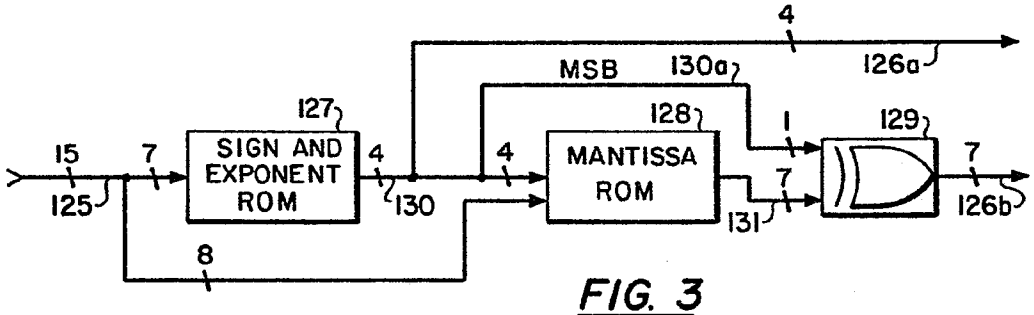


FIG. 3

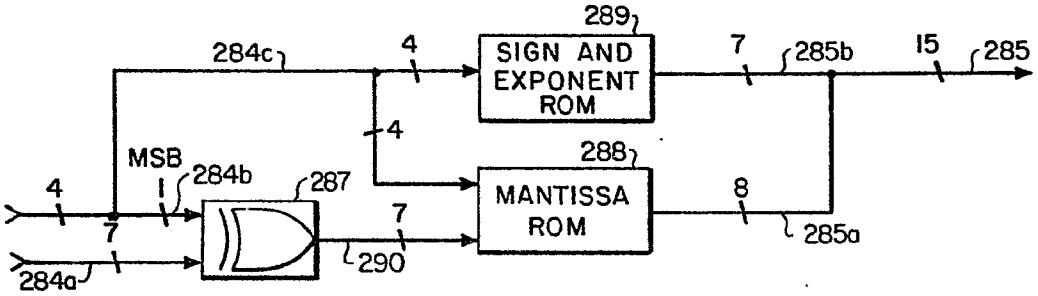


FIG. 7

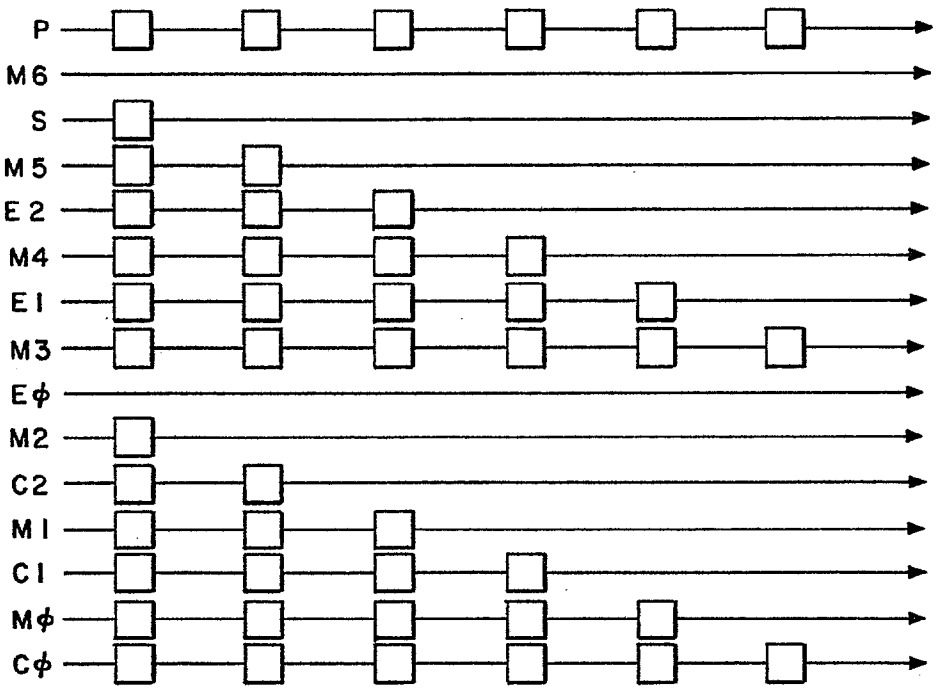

P
M6
S
M5
E2
M4
E1
M3
Eϕ
M2
C2
M1
C1
Mϕ
Cϕ

FIG. 4a

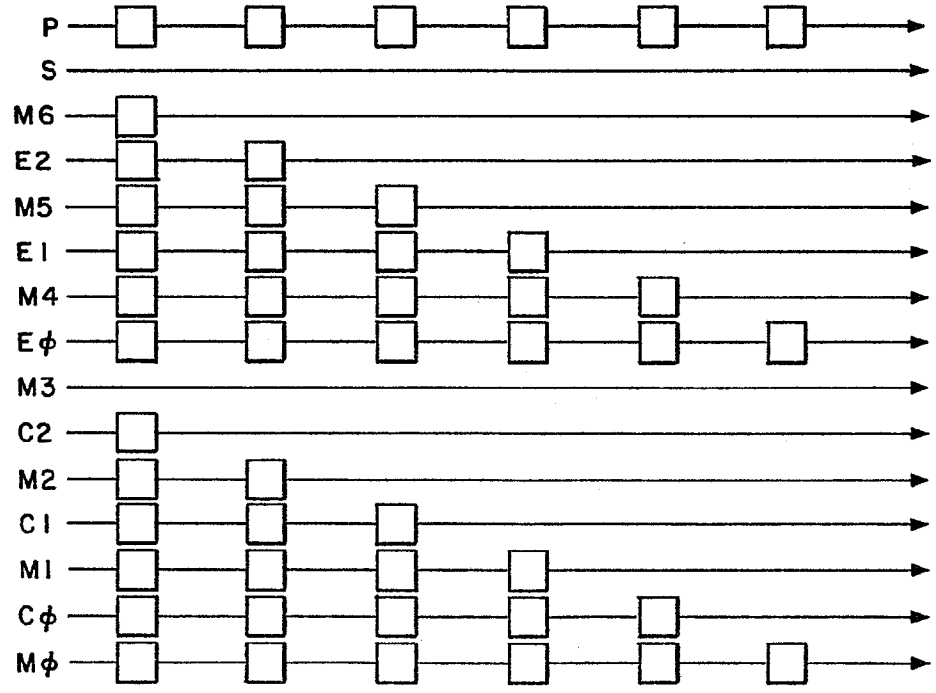

P
S
M6
E2
M5
E1
M4
Eϕ
M3
C2
M2
C1
M1
Cϕ
Mϕ

FIG. 4b

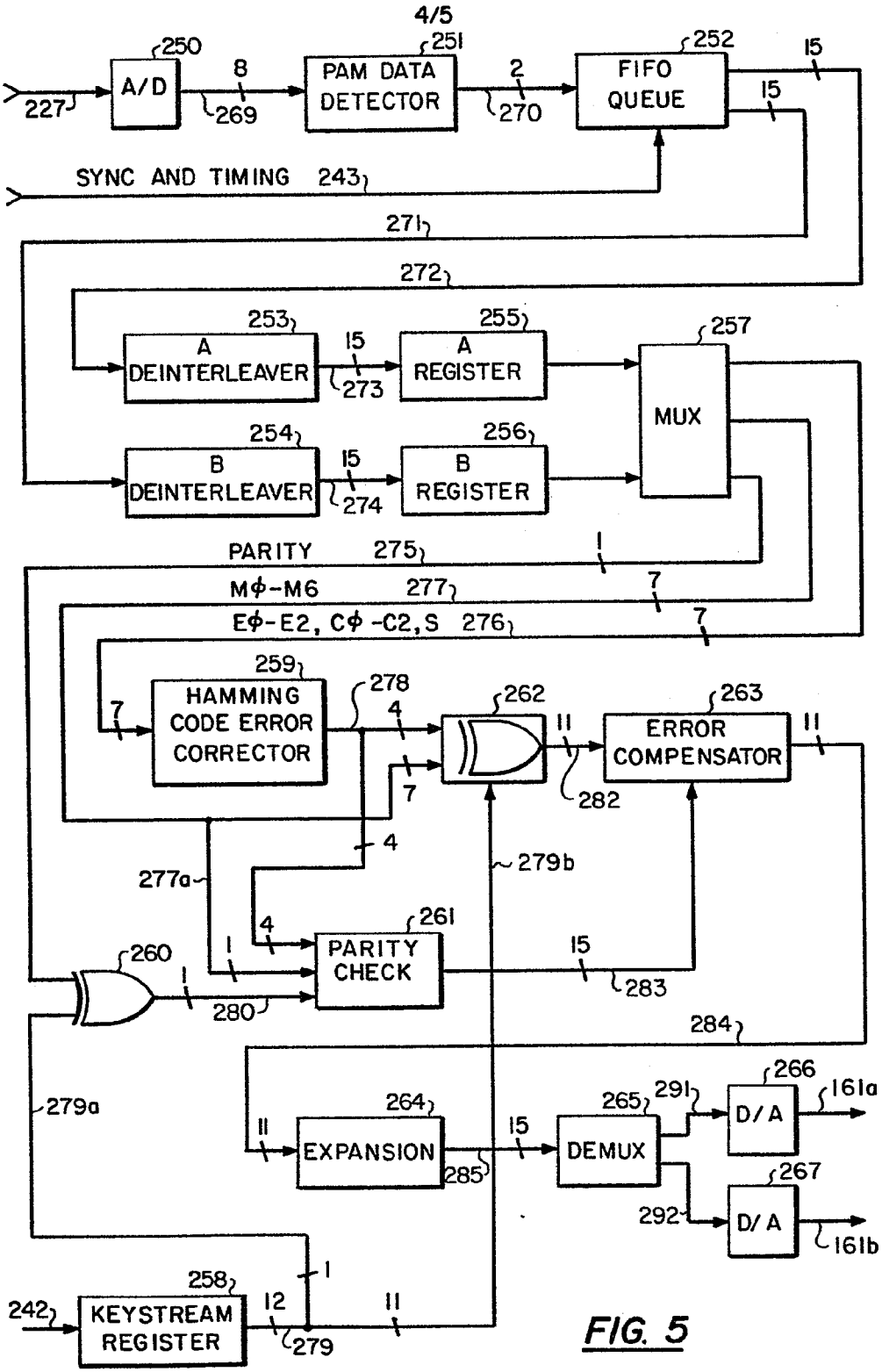

4/5
250
A/D
227
8
269
251
PAM DATA DETECTOR
2
270
252
FIFO QUEUE
15
15
SYNC AND TIMING 243
271
272
253
A DEINTERLEAVER
15
273
255
A REGISTER
257
MUX
254
B DEINTERLEAVER
15
274
256
B REGISTER
PARITY 275
1
Mϕ-M6 277
7
Eϕ-E2, Cϕ-C2, S 276
7
259
HAMMING CODE ERROR CORRECTOR
7
278
4
262
11
263
ERROR COMPENSATOR
11
282
7
4
277a
279b
4
261
PARITY CHECK
15
283
260
1
1
280
284
279a
264
EXPANSION
11
15
285
265
DEMUX
291
266
D/A
161a
267
D/A
292
161b
258
KEYSTREAM REGISTER
242
12
279
1
11

FIG. 5

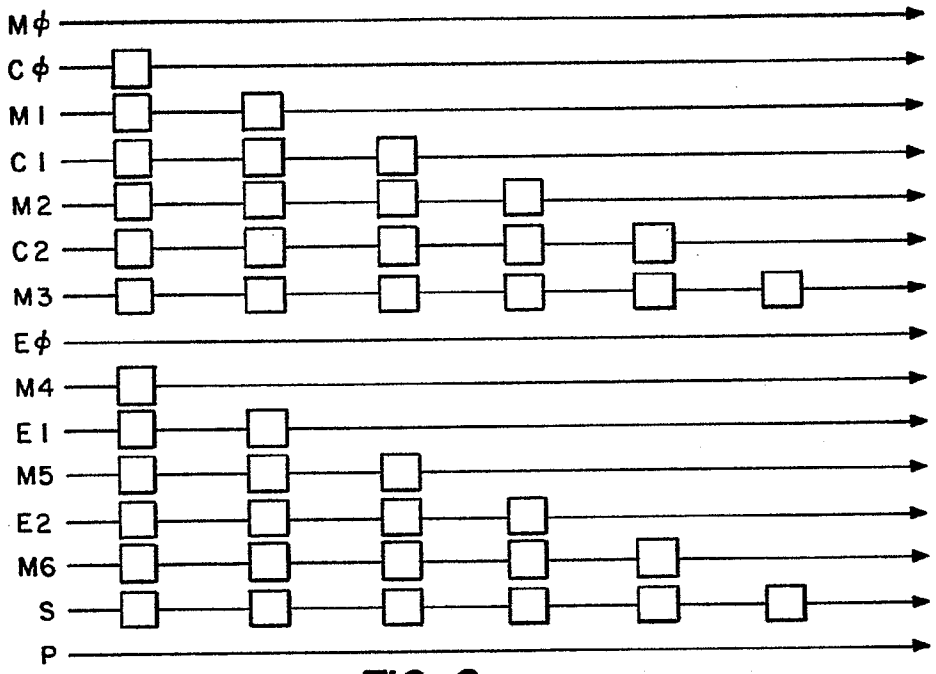

Mϕ
Cϕ
M1
C1
M2
C2
M3
Eϕ
M4
E1
M5
E2
M6
S
P

FIG. 6a

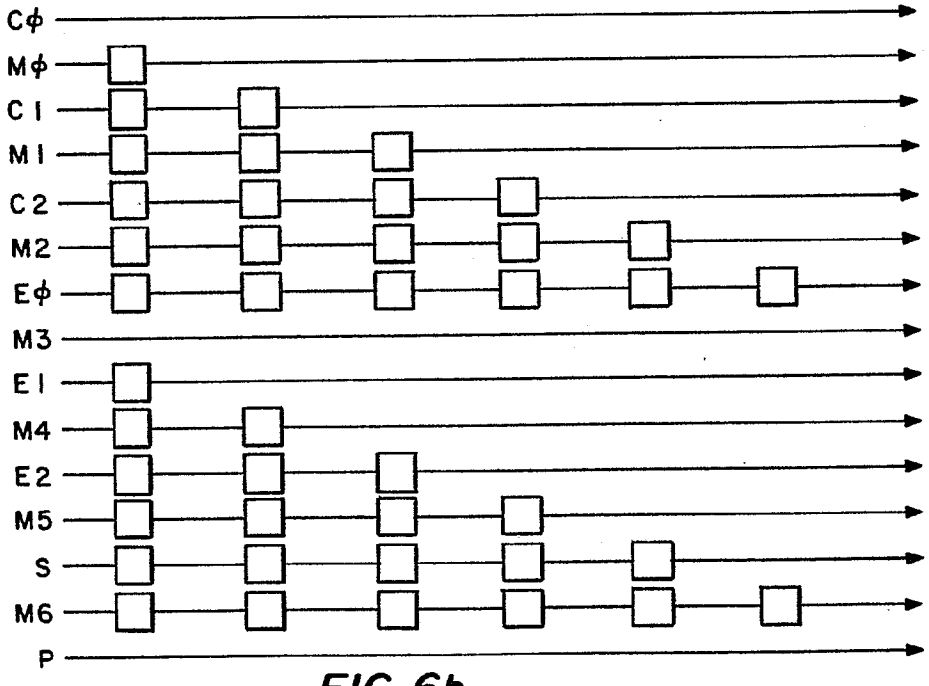

Cϕ
Mϕ
C1
M1
C2
M2
Eϕ
M3
E1
M4
E2
M5
S
M6
P

FIG. 6b

0127382

European Patent Office

EUROPEAN SEARCH REPORT

Application number EP 84303321.8

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
A	EP - A1 - 0 018 783 (WESTINGHOUSE) * Abstract; page 1, line 1 - page 4, line 20; page 12, line 20 - page 13, line 4 *	1,11, 17,33, 35	H 04 K 1/02 H 04 N 7/16 H 03 K 13/02
A	DD - A - 138 457 (AKADEMIE DER WISSENSCHAFTEN DER DDR) * Page 2, line 8 - page 3, line 29 *	1,11, 17,33, 35	
A	US - A - 3 825 893 (BOSSEN et al.)		
A	US - A - 4 171 513 (OTEY et al.)		

TECHNICAL FIELDS SEARCHED (Int. Cl. ³)

H 04 K 1/00
H 04 N 7/00
H 03 K 13/00
H 04 N 1/00
H 04 L 1/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	29-08-1984	HAJOS

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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